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SUMMARY REPORT NO. 4.

MEMORANDA FOR FLIGHT SURGEONS

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Summary reports reviewing the more significant findings contained in reports from service and civilian laboratories in the United States and Allied Countries are issued from time to time. It is the purpose of these summaries to make available to flight surgeons and research personnel a brief survey of the information relating to a certain subject contained in the numerous and often voluminous reports in the files of the Air Surgeon.

C-628, AF

C O N T E N T S

The following information or its equivalent will be especially valuable to all personnel of the Army Air Forces if given to them as demonstration lectures by Unit Surgeons. Such instruction is especially desirable in active theaters where it serves to remind the men of essential procedures. Provision for such instruction is covered in Army Air Forces Memorandum 25-1.

C-628, AF

C O N T E N T S

1. The [illegible] Oxygen [illegible] System.

2. The Control of Decompression Pain.

3. [illegible] (This [illegible] should [illegible] to Air Force [illegible] surgeons).

4. [illegible] on [illegible] of [illegible].

5. Altitude limits without [illegible] oxygen.

6. [illegible] to high altitude.

The following information on [illegible] will [illegible] be [illegible] of the [illegible] Air Forces [illegible] given to [illegible] required by [illegible] information is [illegible] of [illegible] that [illegible] information [illegible]

1. THE NEW DILUTER-DEMAND OXYGEN EQUIPMENT.

Until recently, the majority of U.S.A.A.F. aircraft have been equipped with an oxygen supply system in which oxygen flowed continuously through a manually adjusted regulator -- both during inspiration and expiration. The latest improved form of oxygen regulator is the diluter-demand type in which oxygen is delivered during inspiration only. Thus no oxygen is wasted during the time of expiration. In this system a further economy of tank supply is achieved by automatically mixing appropriate amounts of air with only enough tank oxygen to maintain a normal partial pressure of oxygen in the lungs.

In a demand system without air-mixing pure oxygen flows to the mask whenever the act of inspiration opens the valve contained in the regulator. The suction required to open this valve is very small and oxygen is, therefore, supplied without causing respiratory fatigue, even after long periods of use. The unique property of the demand system is that oxygen is delivered only when the user inhales and in quantities determined by the needs of the individual. Thus, differences in metabolic requirements for oxygen during rest and during work are automatically met. Thus the demand valve supplements the physiological mechanisms which normally adjust the respiratory exchange of gas in accordance with the demands of the body cells for oxygen.

The sole purpose of the air-mixing valve which has been added to the demand regulator is to conserve tank oxygen during flights below 30,000 feet. The degree of opening of the air-mixing valve is controlled by an aneroid mechanism and is thus regulated by the atmospheric pressure. The function of the air-mixing valve is to add air to the oxygen drawn from the tanks in such proportions that adequate alveolar oxygen pressure is maintained at all altitudes up to 30,000 feet. In this way the advantages of the demand system are obtained together with conservation of tank oxygen.

For safety purposes, the air mixing valve is adjusted so that it is closed at approximately 30,000 feet. At this altitude the system becomes a straight demand regulator and delivers essentially pure oxygen to the mask. Therefore, the altitude limitations on the use of this regulator are similar to those of any system delivering pure oxygen, about 37,000 to 40,000 feet.

In using a demand regulator at these high altitudes, it is important to avoid large inboard leakage of air during inspiration. It is imperative that the mask be fitted carefully in order to avoid such leaks. For this purpose, the improved A-10 mask has been developed, after a careful survey of the types of faces that must be fitted. This mask is available in several sizes which enables the unit oxygen officer to fit a mask to almost every type of face. These masks should be personal items of equipment and the wearer should test for leakage

frequently. (See Technical Orders #13-20-1, dated November 9, 1942, and #03-50A-1, dated January 20, 1942).

In an emergency the demand regulator can be changed to a free-flow system by means of an emergency hand control. This control should be employed whenever anoxia is imminent. Oxygen wastage should be avoided, however.

The air-mixing valve can also be closed by hand converting the regulator to a straight demand type at all altitudes. This feature is of use whenever it is important to breathe pure oxygen from the ground up, for example, following denitrogenation for the prevention of decompression symptoms.

Proper use of the demand system of oxygen supply insures freedom from anoxia up to 37,000 feet. With great care in adjustment it is effective at even higher altitudes. Improper use may lead to unconsciousness or death at these high altitudes. Therefore, all personnel using this equipment (A-12 and A-13 regulators, A-9 and A-10 Masks) should study and apply the detailed information contained in Technical Order 03-50-1A, dated November 9, 1942.

In summary. 1. The current demand oxygen system has as its principal virtues the economy of air dilution at lower altitudes, a supply of oxygen adequate for the users needs at all altitudes up to at least 37,000 feet, and a manually operated emergency oxygen flow. 2. Its main objection is that the oxygen mask must be fitted with great care and inboard leakage of air should not exceed 5% of the inspired gas at the higher altitudes. If the leakage is greater than this, the mask should be considered unsatisfactory.

2. CONTROL OF DECOMPRESSION PAIN.

Above 30,000 feet some men are troubled by pains in joints and muscles and by a severe form of pulmonary distress described as "chokes." The higher the altitude and the longer the time at altitude, the greater is the number of susceptible men. Furthermore, the higher the altitude the shorter is the time until symptoms develop. But the rate of climb up to 5,000 feet per minute seems to have little influence on the incidence of these symptoms.

Men can be tested for susceptibility to decompression pain, (chokes and bends), in a low pressure chamber. Such tests show that subjects are not equally susceptible and that an individual's susceptibility can vary from day to day. However, by means of several tests, cadets can be classified according to their relative ability to fly at high altitudes for extended periods without these painful symptoms of decompression sickness. As shown by such tests, some men are particularly suited for high altitude missions, while others are not.

The painful symptoms are thought to be caused by formation of gas bubbles, largely nitrogen, in the tissue fluids. Thus a possible means of prevention of decompression sickness is to remove the nitrogen from the body. This can be done by having the subject breathe pure oxygen before flight. To remove all the nitrogen from the body would take hours, but this does not appear to be necessary. Tests have shown that a useful degree of protection against decompression pain is obtained by 45 minutes of breathing pure oxygen. Some tests show that the efficacy of this procedure is improved if the subjects exercise during the denitrogenation period while others suggest that exercise is unnecessary. If the time available for denitrogenation is short, even twenty minutes of breathing pure oxygen while exercising will afford some protection. Whenever exercise accompanies the denitrogenation procedure, it has been recommended that a fifteen-minute rest period, while still breathing pure oxygen, should precede actual take-off.

In practice the men wear their oxygen masks and are connected by long supply tubes to an oxygen supply. Thus, they are free to move about and indulge in exercise. Once denitrogenation has been started the subjects must continue to breathe pure oxygen in order to prevent return of nitrogen into the body.

The methods of prevention of decompression sickness are not sufficiently standardized to warrant introducing them as a required part of the preparations for high altitude missions. But, whenever time and circumstances permit preliminary denitrogenation, it should be employed. The procedure does not guarantee immunity from decompression pain but will greatly reduce its incidence and delay the onset of symptoms in prolonged flights above 30,000 feet. A period of denitrogenation preliminary to high altitude missions should be regarded as a useful aid in maintaining the efficiency of the air crew.

Tests in low pressure chambers have shown that cold and exercise are both factors in bringing on decompression pain at altitudes above 30,000 feet. Indeed, with even mild exercise almost all men will have painful symptoms within two or three hours. Further tests at -10°F proved that low temperatures also bring on early and severe symptoms even when wearing winter flying suits. The incidence and severity of bends in air crews may be reduced by avoiding unnecessary work and keeping as warm as possible when above 30,000 feet. A corollary of this is that the most susceptible men should, whenever possible, be especially protected from intense cold and heavy work at high altitudes.

3. GET HIM BACK SAFELY

From the Eighth Air Force

Humanitarian considerations are very likely to lead pilots of multi-placed combat aircraft into serious errors of judgment when a member of their crew becomes disabled from wounds or unconscious from lack of oxygen at high altitudes. In the first place, the pilot must make the difficult decision as to whether tactical considerations justify the abandonment of the mission or withdrawal from formation in order to return the wounded man to safety. Provided such a move does not endanger the lives of many other people he may decide to return for medical aid. In that event the pilot's first objective should always be to get the patient back safely rather than quickly. A brief analysis will show why this is true.

A difference of ten or fifteen minutes in getting a wounded man into medical hands will probably not save the life of more than one case in a thousand. As opposed to this, the added hazard incurred in pulling an abnormal amount of power out of the engines to gain speed, or a hurried landing made without carrying out the prescribed landing procedures, will inevitably lead to accidents which will not only jeopardize or destroy the life of the wounded man but also the lives of other crew members.

It is not entirely a question of whether or not the pilot and the balance of the crew are willing to risk their lives for the sake of the wounded man; it is a question of not further jeopardizing the life of the man they are trying to save. Furthermore, killing ten men in an attempt to save one is poor economy of military personnel.

Very similar is the matter of descending to lower altitudes to bring relief to a crew member who has become unconscious through oxygen lack. Here also the first consideration should be to bring the man down safely rather than quickly.

. HOW MUCH TIME YOU HAVE AT VARIOUS ALTITUDES.

The threat to life from being unconscious because of lack of oxygen depends both on the altitude and the duration of the exposure. While no exact data are available, there is considerable evidence to indicate that at around 20,000 feet the average normal individual may endure several hours' exposure without using oxygen and suffer no permanent ill effects, although temporary unconsciousness may result. At around 25,000 feet a loss of oxygen supply will usually result in unconsciousness within a few minutes, but permanent after-effects or death will not be expected until at least one half hour and possibly several hours have elapsed. At 30,000 feet the loss of oxygen supply will usually result in unconsciousness within two minutes or less, but permanent

after-effects or death will not be likely for at least fifteen to twenty minutes and possibly some time longer. At the higher altitudes the danger is increased and the survival time will be less.

With the above in mind it should be obvious that diving an airplane at excessive speed in an attempt to save a crew member who is unconscious from oxygen lack is practically never justified. In such a situation, and where conditions permit, the relief of an unconscious crew member should be brought about by beginning the descent immediately but at a safe rate. To do otherwise may lead to disintegration of the aircraft and death to all its occupants.

At the rate of descent of only 1,000 feet per minute it will require only ten minutes to descend from 30,000 feet to 20,000 feet, at which level the danger to life from oxygen lack is remote for exposures of less than several hours.

WHEN ENEMY FIGHTERS ARE NEAR

On bombardment combat missions at high altitudes where defensive formations are flown as a protection against enemy fighters, the question of leaving the formation and descending to revive a crew member unconscious from oxygen lack must be decided entirely by the possibility of enemy fighter attack. If such attacks are likely, one would practically never be justified in leaving formation, since the risk of destruction of the whole airplane and its occupants would be a possible consequence.

The above is not to be construed to mean that lack of oxygen at high altitude is not dangerous. It is dangerous, but certain methods of relieving it can be more dangerous and should be avoided.

Thus far in this Theater of Operations there is no record of an individual having died directly as the result of oxygen lack or because of a 15-minute delay in receiving medical attention. A number of deaths have been caused unnecessarily, on the other hand, by well-intentioned but misguided efforts to render aid to personnel quickly rather than safely.

4. TREATMENT OF BURNS

The following recommendations on the treatment of burns have been prepared by the Subcommittee on Burns of the National Research Council. The outline of procedure includes information based on recent research and clinical experience:

First-Aid Treatment - primary objectives are:

1. To prevent and combat secondary shock as promptly as possible by plasma transfusion.

2. To protect the burned area, which is an open wound, from further contamination.

3. To minimize fluid loss.

4. To relieve pain.

Surgeon and assistants should be masked. If masks are not available, mouths must be kept closed.

Apply sterile boric acid ointment or vaseline over the burned surfaces. Lay one or two layers of gauze of finest mesh available smoothly over ointment-covered burn. To secure fine meshed gauze, sterile roller bandage can be cut into strips of convenient length.

Remove rings from fingers of burned hands.

Add thick sterile gauze dressings and bandage securely.

Splint the affected part.

Give a sedative to relieve pain. The depressant action of morphine may be dangerous to patients with lung damage or anoxia from other causes.

Sulfadiazine in first-aid pouch should be taken.

Definitive Treatment - primary objectives are:

1. To combat shock by adequate, prompt and rapid plasma administration.

   In patients with severe burns, quantities up to 12 units may be required in the first 24 hours. To the patient in critical condition plasma must be given rapidly (500 cc. in 10 min.) and not allowed to flow drop by drop. Syringe injection may be used.

2. To minimize contamination of the burned area which is an open wound.

3. To remove first aid dressings for definitive treatment.

4. To minimize fluid loss.

5. To continue chemotherapy with special regard to fluid intake and output and renal damage.

Application of definitive treatment implies that time, supplies, and personnel are adequate for carrying out the treatment chosen.

1. "Open" treatment:

   Surgeon and assistants are masked and gloved. Patient is masked, or screened.

With plain soap, soft cotton, and sterile water, area around burn is cleansed gently but as thoroughly as possible. Loose epidermis and foreign material are removed from burned surfaces with sterile forceps and scissors. If burned surface is washed it must be done with minimum trauma. It is not always necessary to wash the burned surface.

Scrub brushes, green soap, vigorous rubbing can do more harm than good.

In most instances, morphine sedation is all that is necessary.

Over the prepared surface apply fine meshed gauze impregnated with boric acid ointment or vaseline. Over this, add sufficient gauze to provide a thick layer that furnishes smooth even compression when bandaged firmly in place. Stockinet or some form of elastic bandage is more effective than the roller bandage.

If an extremity is involved, the dressing starts near the tips of the digits and the digits are separated. Uninvolved tips are left exposed to check for circulation. A splint is added as the final step in the dressing.

Such a dressing, properly applied, can often be left in place 12 to 14 days with occasional "snugging" of the bandage. At the end of that period areas of part thickness loss (second degree) should be healed. Areas of whole thickness loss (third degree burns) may be prepared for grafting by excision of the dead tissue. If suppuration is present, wet dressings may be advisable. Skin grafting at the earliest opportunity is mandatory if the whole thickness of the skin has been destroyed.

2. "Closed treatment" (tanning or eschar treatment):

This method is particularly indicated in extensive flash or second degree burns of the trunk.

This method is recommended:

a. If not more than 24 hours have elapsed;

b. If the burned area has not been grossly contaminated by contact with filthy clothing, immersion in sewage contaminated water;

c. If strict surgical asepsis is employed in preparation of the burned surface; and

d. Only if coagulation is rapidly accomplished, for example with tannic acid spray and silver nitrate.

Slow methods of tanning, such as with tannic acid jelly or tannic acid without silver nitrate, permit absorption of tannic acid with the possibility of serious toxic effects, particularly on the liver.

e. A freshly prepared 10 per cent aqueous solution of tannic acid is sprayed over the burned area. This is followed immediately by spraying the area with a fresh mixture of equal parts of 10 per cent aqueous tannic acid and 10 per cent silver nitrate solutions. This mixture should then be sprayed on the burn every half hour for a total of four applications, or until a satisfactory eschar has been formed. The hands, face, feet, perineum and genitalia should not be tanned. Avoid tanning the normal skin around the burn. While drying, the burned area may be kept exposed to the air under a cradle, heated if in a cold area. After the eschar is dry, it may be covered with a dry sterile dressing.

(When this method is used, the edges of the eschar must be watched for signs of separation on infection. Adequate treatment of the edges either by additional spraying, application of boric acid ointment or vaseline, etc., will prevent the appearance of infection around or under the eschar.) For further information, refer to circular letter No. 15, issued January 11, 1943 by the Surgeon General's Office.

APPENDIX TO ITEM 4

FIRST AID FOR BURNS

Air Corps personnel can do a great deal to protect themselves and their comrades from serious consequences of even severe burns by instituting preventive measures and administering effective first aid.

The causes of burns in the Air Forces are primarily:

1. Flame burns from burning gasoline.

2. Burning by gasoline splashed on the skin.

3. Incendiary bomb flashes.

4. Phorphorus burns.

Most often the hands and face are the most severely burned while deep burns occur less frequently in covered portions of the body.

Burns are classified according to depth, area, and location of the injury because these are important factors in determining the proper treatment. A first degree burn usually occurs from brief exposure to intense heat or prolonged exposure to mild heat. The skin appears red and blistering may develop in some areas. Pain and itching may be severe until the inflammation subsides. A second degree burn is deeper, involving more than the upper layers of the skin. However, there remains in the burned area many living patches of the deep skin layers (dermal layers) from which new skin can develop. A second degree burn may be expected to heal rapidly. A third degree burn is one destroying the full thickness of the skin and may involve the underlying muscles and other tissues. In this case, new skin must grow inward from the edges of the wound. This makes healing a much slower process.

The total area of body surface involved is very important in determining the severity of a burn and especially its effects on other parts of the body (systemic effects). The amount of toxic material entering the body from the burn, as well as the chance of infection from outside, are both related to the total area of injured skin.

In addition, the location of the burned area is important in determining the method of cure. Burns on the hands, face, genitalia, and areas of skin that are stretched or relaxed by bending joints require special consideration since at least a near perfect recovery is required if the part is to perform its normal function. Burns on the trunk are more readily treated and the requirements for effective recovery are less exacting. Furthermore, it has been found that burns on the back are less severe in their total effects than equally burned areas on the chest and abdomen.

Accordingly, it has been found convenient to divide burns into two general types: (1) A minor burn is of the first or second degree type but involves less than 1% of the body surface, (28 square inches) unless it occurs on hands, face, flexures, or genitalia; (2) All burns, of whatever degree, in these areas, as well as those covering more than 1% of the body surface elsewhere, are classified as major burns.

From this information, it is obvious that several precautions can be taken to prevent or at least reduce the severity of burns. One procedure is effectively to cover the body, especially the most vulnerable parts, such as the eyes, face and hands. Ordinary clothing affords some protection to most of the body. The pilot who in addition always wears goggles, oxygen mask, helmet and gloves is giving himself the best chance of avoiding major burns.

FIRST AID FOR BURNS

In the intelligent application of first aid to a burned man, it is important to remember that the harmful effects of a burn are not all localized in the wounded area. Here is the primary source of trouble but, in addition, there are general effects on the rest of the body identified as shock. First aid to the victim of burns must treat (a) the shock and (b) the wounded areas.

Procedure.

1. Primary shock is characterized by a fall in blood pressure, feeble pulse, clammy skin, and a subnormal temperature. It usually occurs immediately after the burn and is of nervous reflex origin. It is probably associated in part with the intense pain from the burn. Therefore, the first objective in first aid should be to relieve pain by the use of morphine and to keep the patient as warm and inactive as possible. Clothing should not be removed until after recovery from primary shock, i.e. when the pulse is strong and the pain reduced by morphine. Morphine is given in accordance with instructions in AAF Memo 25-1A.

2. Secondary shock involves the whole body but develops more slowly. Plasma transfusion should be given at the earliest possible moment to combat secondary shock. This usually develops from one to two hours after injury, thus allowing some time to reach a place where plasma transfusion can be administered by one experienced in the technic.

3. Any burned area is an open wound, and steps must be taken to (a) clean it or (b) at least prevent further contamination. This should be done so that interference with later medical treatment is avoided:

   a. Apply sterile vaseline or boric acid ointment over the burned surface. Cover with sterile fine-meshed gauze. Add several layers of bandage and bind firmly but not tightly. The part should not be moved, and, in the case of involved extremities a splint should be applied if possible.

   b. Sulfadiazine should be taken.

   c. Tannic acid or other coagulants ordinarily are not applied to burns as part of the first aid treatment, as they may interfere with certain types of medical treatment that may be employed when the patient reaches a base hospital.

4. In the special case of phosphorus burns, small particles imbedded in the skin will continue to burn as long as air reaches them. Immerse the part in water or apply water-soaked dressings to stop the burning.

During flight, the administration of first aid may be extremely difficult. In general, the less an injured man is disturbed the better. The patient should be kept as warm as possible and be given hot drinks if available. Administration of oxygen will help. Ordinarily, the clothing should not be removed. The usual treatment of exposed burned areas should be given. For the relief of pain, use the morphine provided in the first aid kits. Remember that you will usually have one to two hours to get the man to a place where the complete first aid treatment previously outlined can be given.

5. ALTITUDE LIMITS WITHOUT SUPPLEMENTARY OXYGEN

Extensive investigations have been made of the relation between the physiological condition of men and the degree of oxygen saturation of their arterial blood. From these studies, it is concluded that the first detectable deviations from normal performance occur on the average when the arterial blood is about 92% saturated. Unconsciousness is not imminent, however, until the saturation is reduced to about 70%. It is estimated that flying can be carried out at 85% saturation, and this value has been designated as the minimum safe level of arterial oxygen saturation.

These findings can be translated into altitude limits. Thus 92% arterial saturation obtains at 6000 feet in the average man, breathing air. At 10,000 feet, his arterial saturation will be about 85% and at 17,000 feet, it will be 71%.

Careful consideration of these results and many others has suggested the advisability of revising the directions in Technical Order 03-05-1 on the use of oxygen. It is recommended that supplementary oxygen be used at all times in flights above 10,000 feet.

A further recommendation refers to the use of oxygen in night flying. Tests have shown that night vision is adversely affected as low as 5,000 feet when breathing air. For this reason, it is recommended that oxygen be breathed from the ground up during night flying.

6. BAILING OUT AT HIGH ALTITUDE

This communication concerns the problem of bailing out at 30,000 feet without special oxygen equipment.

Three types of experimental descents have been tested in a low pressure chamber:

1. Open parachute descent from a simulated 30,000 feet while breathing freely.

2. Open parachute descent from 30,000 feet with previous hyperventilation before starting down and then holding the breath as long as possible after the oxygen supply was cut off.

3. Free fall for as long as the subjects could hold their breath after previous hyperventilation with pure oxygen. The open parachute descent was begun as soon as the subjects breathed.

These tests show that it is possible for a man to descend in an open parachute from 30,000 feet without oxygen equipment and without losing consciousness.

In this maneuver, it is desirable to hyperventilate with pure oxygen before leaving the oxygen supply in the plane. This procedure washes out carbon dioxide from the lungs and subsequently enables the pilot to hold his breath for a longer period than usual. Even four or five deep breaths, taken over a period of thirty seconds, will significantly increase the time that a man can hold his breath. As soon as the hyperventilation is finished, the pilot should fill his lungs with oxygen, hold his breath, and leave the plane as quickly as possible.

A man can free fall from 30,000 feet without danger of collapse from anoxia. If he holds his breath while free falling and opens the parachute at the time of his first breath, the degree of anoxia produced will be minimal. There is on record at least one case of such a procedure being successfully employed during an emergency descent from 35,000 feet.

The greatest variable in this procedure is the degree of work required to get out of the plane. For this purpose an emergency walk-around oxygen bottle should be kept at each station. This can be used to supply oxygen up to the moment of leaving the plane. Under these circumstances, the descent will not produce a dangerous degree of anoxia, especially if breath-holding is employed.

The safest procedure is, of course, to free fall as long as the breath can be held and then pull the rip-cord. In this way the subject reaches, in the shortest possible time, levels of air pressure that will supply him with sufficient oxygen. It is important that the rip-cord be pulled just before he takes his first breath of rarified air. In this way he will descend safely even if he has become temporarily anoxic by breathing rarified air.

In certain studies, it was found that men could hold their breath for the same length of time while breathing oxygen at 30,000 feet as when breathing air at sea level. This was to be expected since it is the accumulation of carbon dioxide which forces a man to breathe after holding his breath a while. Pilots should be encouraged to practice holding their breath occasionally while on the ground. Each man can determine for himself how long he can hold his breath normally, and how much longer this time is when he washes out his carbon dioxide by several deep breaths. This practice has the beneficial effect of familiarizing the men with the procedure. Indeed, frequent practice improves a man's performance as shown by training for swimming under water. The interest of the men in this personal testing will be increased by pointing out that from the times, thus determined, they can estimate the altitude attained in free fall and in parachute descent from any initial altitude. If the altitude is 15,000-20,000 feet or less when the first air is breathed, there will be no serious anoxia.

By free falling a man will descend approximately 10,000 feet per minute. If he bails out at 30,000 feet and holds his breath for one and one-half minutes, which most anyone can do, he will have reached an altitude of 15,000 feet at which height he need not fear anoxia. Should one bail out at 35,000 feet and free fall for one and one-half minutes while holding his breath, he will reach 20,000 feet before opening his parachute and still be relatively safe from anoxia.